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Many in situ measurements at sea are made using instruments tethered to a ship with an electromechanical cable. As the ship moves in response to the surface waves, the supporting cable transmits the motion to the instrument. This ship-induced motion is a source of error in the measurements and is a source of mechnical failure that has led to the loss of instruments.

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Naval Ocean Research and Development Activity

NSTL, Mississippi 39529 NORDA Report 91 February 1985

An Active Winch Control System for Ship-Induced Motion Isolation

Final Report

Kim D. Saunders

Oceanography Division
Ocean Science Directorate

Foreword

High-precision oceanographic measurements, especially those dealing with nonexpendable profiling instruments, are often difficult to make because of ship motions. In 1982, efforts to overcome this problem were undertaken and work on a motion compensation system started. Portability and low cost were primary design constraints.

This report covers the development of an active winch control system that should help solve the problem of motion isolation.

R. P. Onorati, Captain, USN
Commanding Officer, NORDA

Executive summary

Many in situ measurements at sea are made using instruments tethered to a ship with an electromechanical cable. As the ship moves in response to the surface waves, the supporting cable transmits the motion to the instrument. This ship-induced motion is a source of error in the measurements and is a source of mechnical failure that has led to the loss of instruments.

To reduce the effect of ship-induced motion on an instrument package, an electrically controlled winch system was developed to provide motion compensation. An electrohydraulic winch is controlled by a micro-computer using a combination of open- and closed-loop control strategies.

The winch was tested during a cruise in the summer of 1984. The ship-induced motion was reduced by factors of 2-3. Further improvement is required and some means for achieving that improvement are proposed.

Acknowledgments

The author gratefully acknowledges the generous advice of Dr. A. W. Green. The testing of the winch could not have been accomplished as expeditiously as it was without the assistance of Dr. Henry Perkins, Bill Teague, Steve Sova, and Edward Mosevich. CAPT Kim Giaccardo, the officers, and the crew of the USNS BARTLETT gave invaluable assistance and advice. This project was funded under program element 61153N, Dr. Herb Eppert, program manager. The NORDA technical editing staff under Doug Johnston provided the support work in assembling this report. Their unfailing high levels of competence and personability contributed greatly to this report.

Contents

An active winch control system for ship-induced motion isolation

1. Background

Most high-precision, nonexpendable oceanographic profiling instruments are directly tethered to a ship by an electromechanical cable. Ship motions, primarily roll and heave, cause the descent rates of such profilers to vary by up to several meters per second. The variations in descent rates cause significant errors in measurements of temperature, conductivity, and velocity (Gregg et al., 1982; Trump, 1983). These errors could be reduced if the profiler were uncoupled from the ship's motion.

Both passive and active systems have been used in the past. Kidera and Mack (1983) describe a passive pneumatic system designed and built at Johns Hopkins Applied Physics Laboratory. Gargett (1978) mentions a feedback-controlled winch built by the Defence Research Establishment (Canada) and used in 1972 and 1973 for towed temperature microstructure measurements.

In early 1982, it became apparent that to make high-quality, finescale measurements of velocity, temperature, and conductivity, a motion compensation system would have to be built. Portability and low cost were primary design constraints.

We first considered a passive system. A very compliant system was required for motion isolation. At the same time, the system had to support the loads of several thousand meters of electromechanical cable required for deep casts. Thus, the system had to be compliant at ship-roll frequencies and very stiff at cast-repetition frequencies. It did not appear that a low-cost passive system could be built with such a response.

The active system approach was taken. After considering both a hydraulically controlled active boom and an electrically controlled active winch, the active winch was chosen. It is interesting to note that Berteaux and Walden (1984) and Trump (1983) also came to the same conclusion at about the same time.

2. System design

The active winch motion isolation system consists of three parts: a suite of sensors to determine the system state and input variables, a controller, and an electrically controlled winch.

Open-loop control is achieved by adjusting the speed of the cable at the winch to balance the vertical motion of the ship at the point where the cable leaves the ship (the main block under normal circumstances). This velocity is estimated by integrating the output of an accelerometer mounted near the main block. This output is digitized by the control computer and the winch rotation rate is controlled by creating an analog voltage, which is sent to the control section of the winch.

The integration of the accelerometer output is performed by an analog circuit. Voltage offsets, which are partially removed by a long-term running mean in the control computer, are invariably introduced at this stage. Nevertheless, long-period fluctuations do occur and cannot be corrected unless the loop is closed.

Closed-loop control is obtained by comparing the observed pressure (Pobs) at the profiler with a desired pressure (the control variable, Pc). For a constant descent rate, $Pc = Po + W^*t$, where W is the descent rate in decibars per second, t is the time measured in seconds from the start of the cast, and Po is the pressure at the start of the cast. The error signal, $e = Pc - Pobs$, is computed and the rotation rate of the winch is modified by a factor proportional to the error signal.

This control description is shown schematically in Figure 1, and the algorithm for the winch rate is given by:

$$R = K0^* (W + K1^* (V - Vav) + K2^* (Pc - Pobs)),$$

where

- R = the winch rotation rate in Hz,
- $K0$ = a factor relating rotation rate to wire speed,
- W = desired descent rate,
- V = estimated ship velocity,
- Vav = running mean of V,
- $K1$ = proportionality factor for open loop control,
- $K2$ = proportionality factor for closed loop control,
- Pc = desired pressure (= $Po + W^*t$),
- $Pobs$ = observed pressure at the profiler.

The control design was implemented by hardware consisting of a Z-100 computer system with appropriate interfaces, which are described in more detail in the following sections.

The overall system configuration is shown in Figure 2 as a connection diagram.

3. Winch

An electrically controllable, seagoing winch capable of rapid response and of speeds and accelerations appropriate for expected ship motions was required for this system. The speeds and accelerations were chosen, based on observations from the Neil Brown Instrument Systems/NORDA Velocity Conductivity Depth Profiler (VTCD) accelerations and pressure records on earlier cruises. These specifications (Appendix A) were based on these data as well as specifications for an earlier winch procured by NAVOCEANO.

An open bid procurement for the winch was initiated in 1982. Three bids were returned. One bid was rejected as unresponsive (it did not meet the specifications). Of the other two, the lower cost bid was chosen. The contract was awarded to the SEA-MAC Marine Products Division of Harvey-Lynch, Inc., Houston, Texas. The contract price was $45,482.

"The winch is powered by a 30 HP 460 VAC/3 Phase electric motor which is coupled to a closed loop hydraulic pump and charge pump assembly to operate a hydraulic motor which in turn is coupled though a multiple disc failsafe automatic brake and planetary gear reducer directly to the cable drum." (SEA-MAC, 1983).

Winch control is provided via a Sundstrand/Honeywell controller. The controller is designed to operate with a center deadband, which must be compensated for by the control computer. When the winch was delivered, a series of tests were made to determine the winch rotation rate as a function of the control voltage (Fig. 3). Several points were rerun during the at-sea tests, and no change from the original function was found.

4. Control section

A. Sensors

Accelerometer

The accelerometer was a Kistler Model 303G.5 servo accelerometer, which was salvaged from a vintage 1975 wave sensor package. The exact reponse of the accelerometer is not known, but the output appears reasonable in near-static situations.

Pressure sensor

The pressure sensor is part of the VCTD. This instrument was built by Neil Brown Instrument Systems, Inc. (NBIS), Cataumet, Massachusetts. The pressure sensor is a Paine Instruments, Inc., bonded strain gauge absolute pressure transducer. It has a range of 0-320 decibars, full scale, and the data are digitized in 12 bits. The least significant bit level is equivalent to 0.005 decibar. The accuracy is quoted as 0.1% full scale (0.32 decibar), and the noise as less than 0.0015% full scale (resolution is quoted as 0.0015% full scale) (Neil Brown Instrument Systems, 1979).

The pressure is digitized by the profiler circuitry, converted to serial frequency shift key (FSK) code, and transmitted via the electromechnical cable to a deck unit on the ship. The deck unit demodulates the FSK code, converting it to serial and then to parallel digital code. The parallel digital code is transmitted to the controller via a general-purpose interface bus (GPIB or IEEE 488 bus). The computer interfaces to the bus via a GPIB/S100 bus interface.

B. Analog interface circuits

Buffer and offset amplifier

The accelerometer provides an output proportional to the sensed acceleration. The predominant acceleration sensed is gravity. Because we are interested only in variations from this mean, to remove it is advantageous. The circuit used for this purpose is shown in Figure 4. The signal is first attenuated by a factor of 1/2. An offset is added/subtracted, as appropriate, to bring the mean to zero volts. The signal is then amplified by a factor of 4 to double the original value without the mean due to g. The follower form of the amplifier used here also provides a high-impedance, low-capacitance buffer between the amplifier and the subsequent circuitry.

Integration filter

This circuit provides a voltage proportional to the instantaneous vertical velocity of the ship at the accelerometer. Because the offset circuit in the previous example cannot completely eliminate the mean output of the accelerometer, a differentiator/integrator filter is required. This circuit removes long-period variations in the signal by acting as a low-frequency differentiator while integrating the signal over the frequency bands of interest—in this case, the ship roll frequency band. The circuit is shown schematically in Figure 5. The capacitor between the amplifier output and the ground was required to damp very-high-frequency oscillations that were observed when the circuit was connected to the analog-to-digital interface.

Output buffer/power amplifier

To provide a buffer between the digital-to-analog board in the control computer and also to provide sufficient current to operate the Sundstrand controller on the winch, a power amplifier/buffer amplifier circuit was employed.

Figure 6 shows the schematic diagram for this circuit. Provision was made for either attenuation or amplification, but no attenuation was made, and unity gain was used.

C. Computer and digital interfaces

Z100 computer

The heart of the control circuitry is a Heath-Zenith Z100 microcomputer. This is a 16-bit machine based on the INTEL 8088 microprocessor. The system is configured with 392 K memory. The GPIB drivers were written in assembler language for the 8088, while the main control program was written in compiled BASIC and linked with the appropriate drivers. The control software is listed in Appendix B.

The Z100 communicates with other devices via an IEEE 696 bus (otherwise known as an S100 bus). All interfaces to the sensors and controllers must be S100 bus compatible.

GPIB/S100 bus interface

A National Instruments GPIB-696 interface board is used for communication with the profiler deck unit to obtain pressure data. This board is well documented, but does not come with software in useful form (some listings of drivers in assembly language are given, but they are incorrect). I revised the drivers, which are included in Appendix B.

Analog-to-digital/S100 bus interface

The output of the acceleration integration filter is passed to the computer via a DUAL Systems Corporation analog-to-digital converter, Model AIM-12. This is a 32-channel, 12-bit, -10V to $+10$V A-D converter, S100 bus compatible. The conversion time is 25 microseconds (μsec) (typical).

Digital-to-analog/S100 bus interface

The control computer output is via a DUAL Systems Corporation digital-to-analog converter, Model AOM-12. This is a 4-channel, 12-bit -10V to $+$ 10V, D-A converter, S100 bus compatible. The conversion speed is about 5 μsec.

5. Test results

The active winch control system was first tested on Cruise 708-84 aboard the USNS BARTLETT as part of the Fine-scale Variability Experiment (FSV-84). The operation period was 1-19 August 1984. The operation area was the western North Atlantic in the vicinity of 30°N, 74°W.

The winch was located on the afterdeck, approximately on the center line of the ship. The electromechanical cable was lead aft to the main block, which was hung from the center of the "U" frame on the stern. Initially, the accelerometer was mounted on the block. Later, it was moved to a post on the stern.

To determine the best coefficients for the control algorithm, I first ran the system under open loop control. The test results are presented in Figure 7. The vertical axis is pressure in decibars, the horizontal axis is time in seconds. K1 is the open loop proportionality factor, as described in the control design section. The intent of this test (and all subsequent tests) was to hold the profiler at a constant depth. Under manual operation (no control, winch stopped) the profiler had vertical excursions of about 0.5-1 m. With the controller on and the K1 factor set at 0.25 the wave motion was greatly damped, but at the expense of a very long period oscillation (on the order of about 100 sec). The maximum amplitude at wave periods appears to be about 0.3 m, and typically much less. The long-term oscillations seem to be due to either the imperfect operation of the filter or to a side effect of the running mean (which had a length of about 100 sec). Other values of K1 were tested, but the best value was near 0.25. (It should be noted that this value will change whenever the input amplifier gain is changed, the offsets are changed, or the accelerometer gain is changed. All these values changed later in the cruise when the first accelerometer failed and the new one was installed on a post fixed to the stern.)

While the open loop approach is beneficial in reducing the package motion at wave periods, it also introduces serious long-term fluctuations. These long-period oscillations may be removed by closing the control loop. The next tests of the system were under closed loop control with open loop velocity compensation. The results of one of these tests (made after the accelerometer was changed and moved) are shown in Figure 8. As in Figure 7, the vertical axis is the pressure (in decibars) measured at the package and the horizontal axis is time in seconds. The first section of the plot illustrates the vertical excursions of the profiler under closed loop control. The large oscillations occurring before about 50 sec are due to the transient behavior of the startup phase of the control program (required to ensure smooth starting of the winch and to reduce the probability of the cable jumping the sheave). After about 350 sec of operation, the controller was stopped and the profiler returned manually to the original depth. The rest of the record was made with the winch stopped.

From this figure, we can see that the closed loop control gave a definite advantage over the no-control situation

By visual inspection, the controlled excursions appear to be about ½ to ⅓ those experienced when no control was exercised.

6. Development plans

The tests described were of the first version of the control system. The response of the system under closed loop control was good, but not as good as desired. Considerable improvement can and should still be made.

One of the possible sources of error is directly attributable to noise in the pressure signal. Occasionally, the pressure will appear to jump by as much as 0.3 decibars between samples, which is equivalent to a vertical speed of about 4.8 m/sec—clearly an erroneous reading. The effect on the winch control of such spurious points is severe and should be removed by the software. The algorithm for detecting and correcting spurious pressure data has not yet been incorporated into the control program.

Another source of error may be attributed to the effective sampling rate of the pressure. With the present setup, the system state was updated only at about 6-7 times per second. No smoothing filter was applied to the output, which may have led to jerky winch response.

I intend to improve the system response by increasing the effective speed of the processor by adding an INTEL 8087 arithmetic coprocessor to the system to handle the floating point operations and time critical fixed point operations. An analog pressure channel is planned for the VCTD deck units and direct analog-to-digital conversion will be used, rather than the more cumbersome (and slow) GPIB software. (This feature will also permit some prefiltering of the pressure signal, if required, to suppress the "wild" points.)

Also, better accelerometers will be used rather than using salvaged ones of unknown history and quality.

The accelerometer output will also be calibrated on a velocity test facility at NSTL, and the amplifers and filters will be more precisely calibrated. An output filter stage will be added to the D-A converter to smooth the voltage to the winch. The winch itself will be serviced and adjusted for smoother operation.

Finally, if time and money permit, the actual winch response under load will be measured and incorporated into any modifications of the control model.

7. References

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SEA MAC Marine Products Div. of Harvey-Lynch Inc. (1983). *Operations and Maintenance Manual for NORDA Winch*. Houston, Texas.

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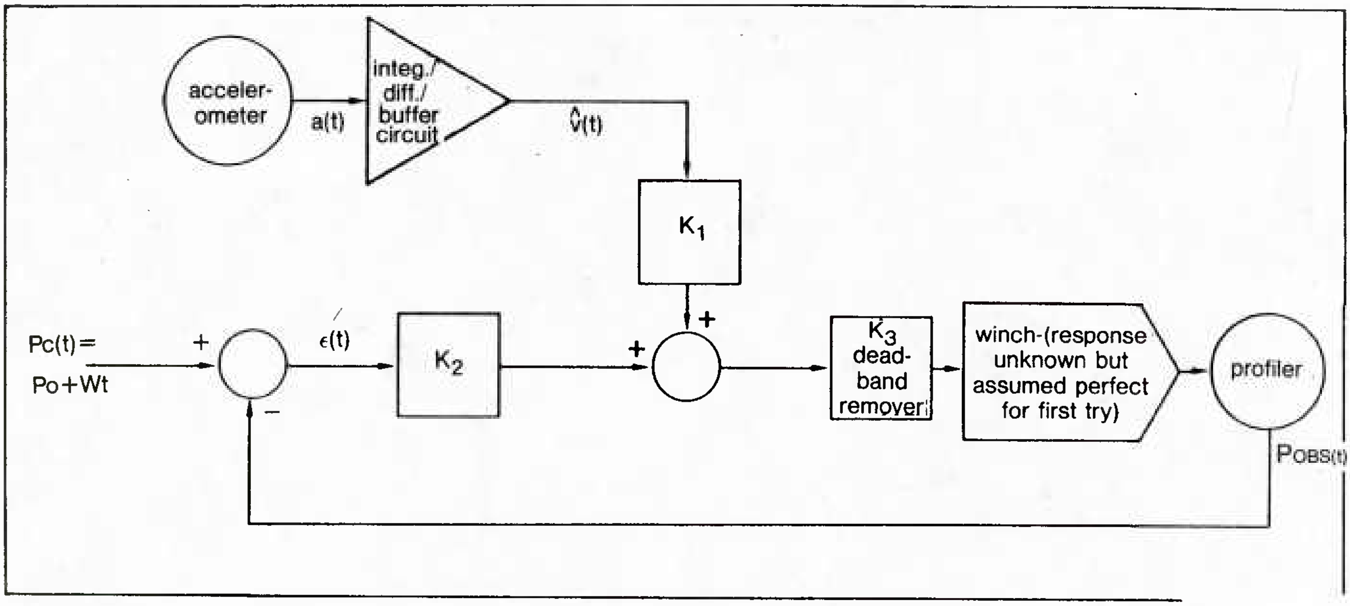

Figure 1. Schematic diagram for motion isolation winch control system.

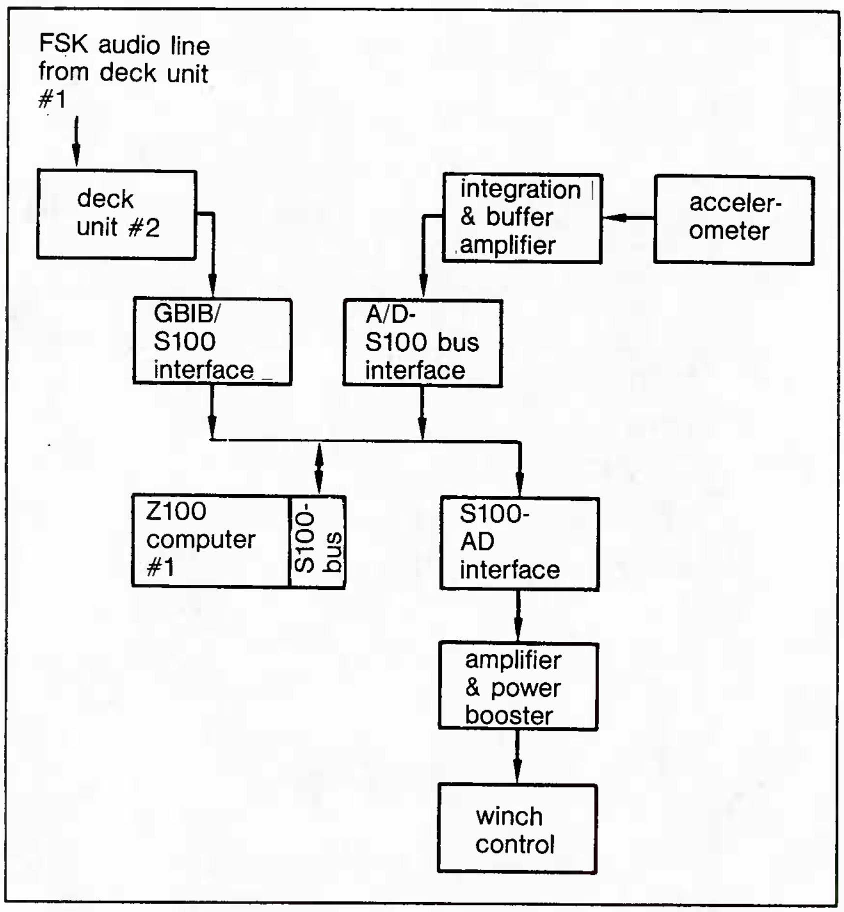

Figure 2. Schematic diagram for equipment connections in the winch control system.

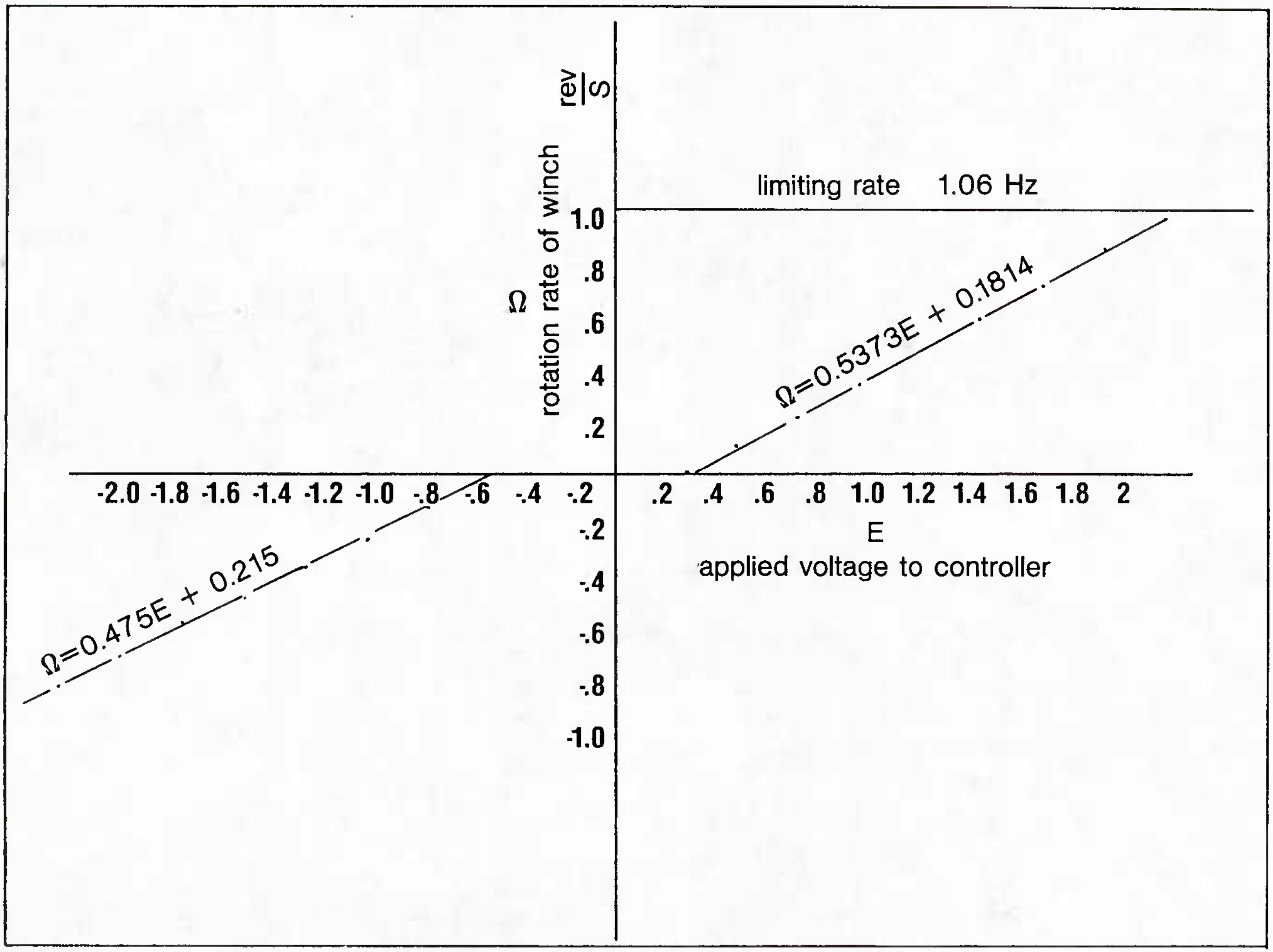

Figure 3. Winch drum rotation rate as a function of control voltage.

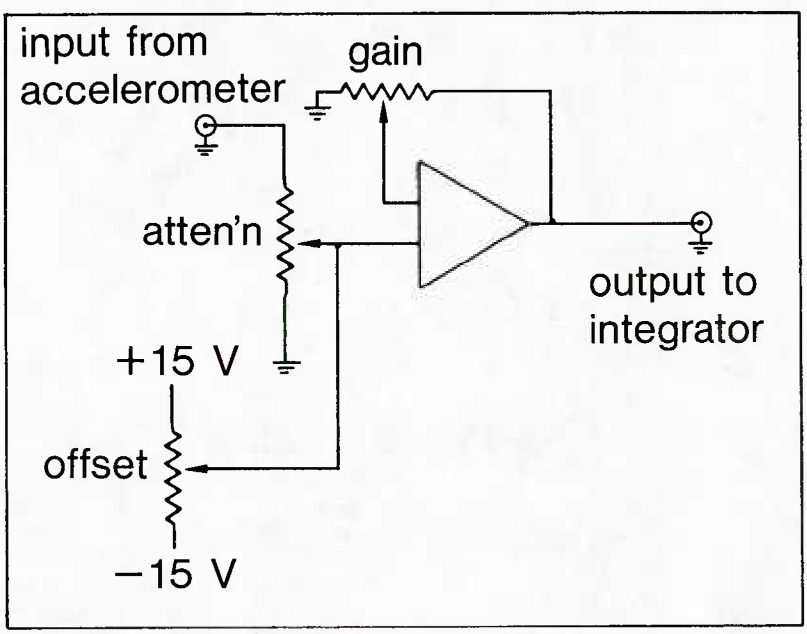

Figure 4. Schematic diagram of buffer/offset amplifier.

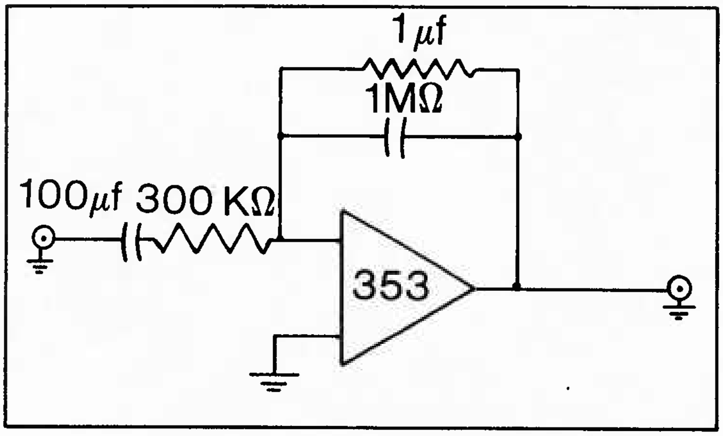

Figure 5. Schematic diagram of integration filter.

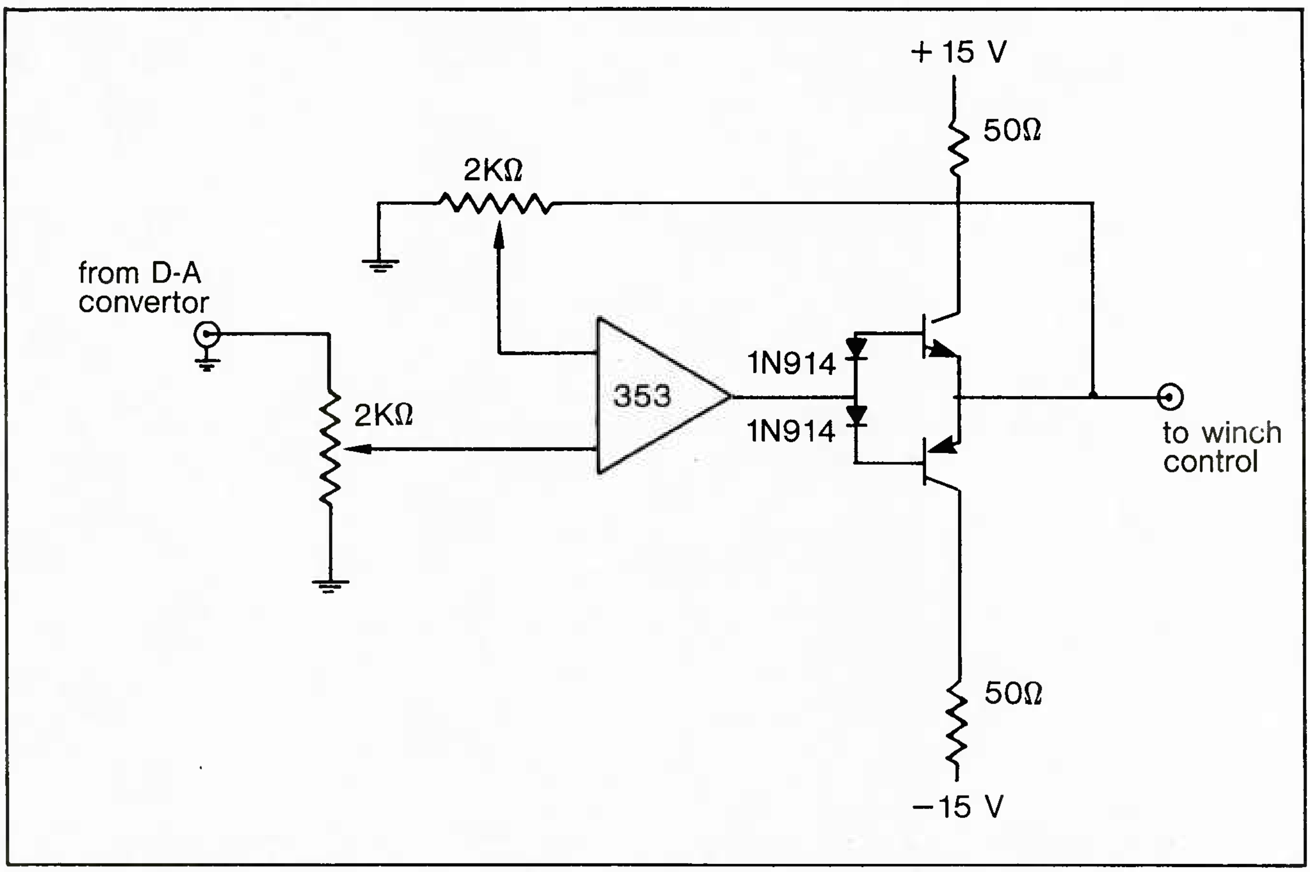

Figure 6. Schematic diagram of output buffer/power amplifier.

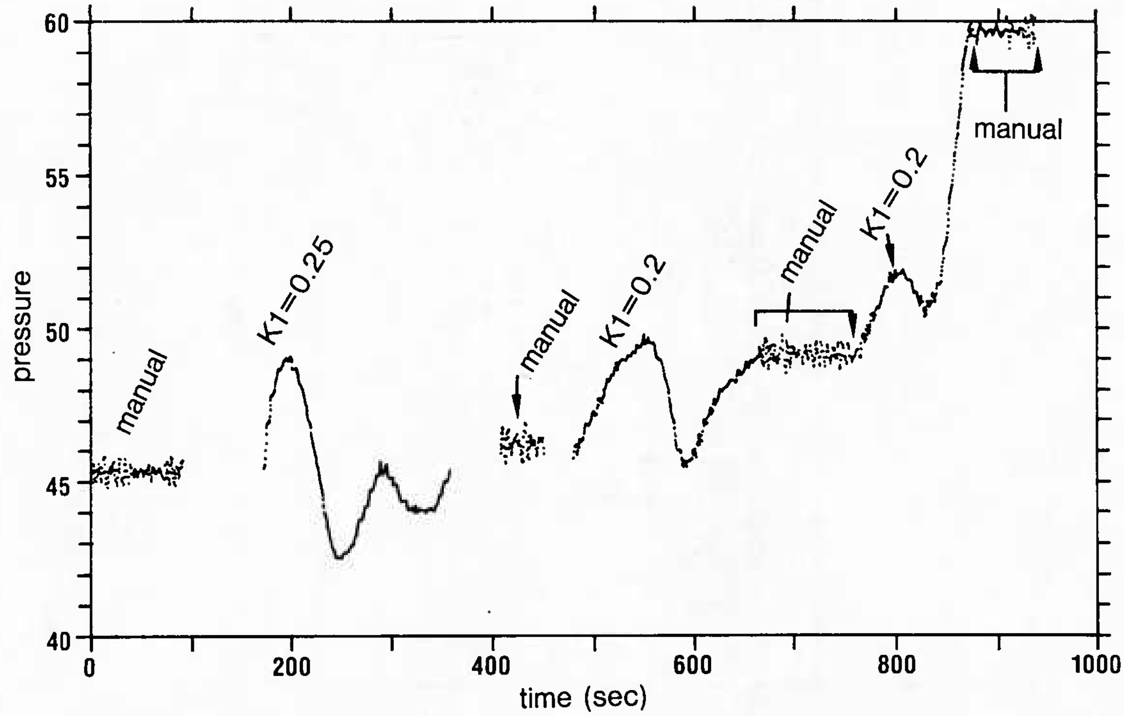

Figure 7. Example of an open loop test. Note the great attenuation of the ship-induced motion evidenced near the maxima and minima of the long-period oscillations. The oscillations are artifacts of the control process and imperfect filters.

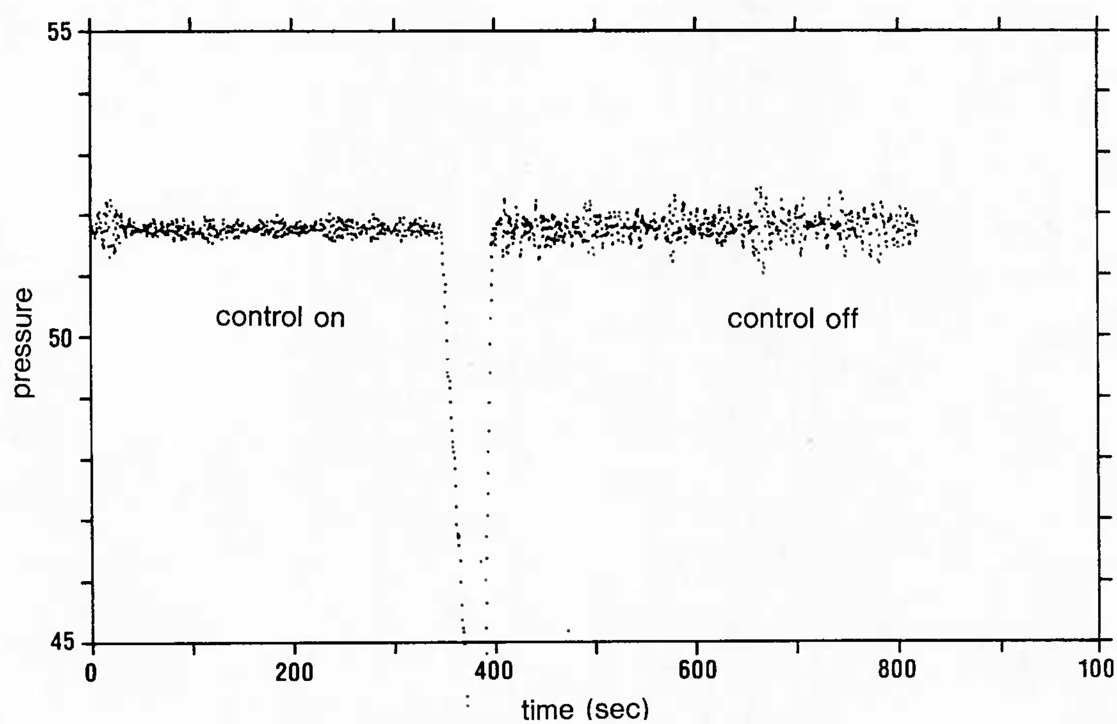

Figure 8. Comparison of closed loop control with no control. The rms amplitude of the profiler under closed loop control is about ½ to ⅓ that under no control.

Appendix A: Specifications for a variable speed oceanographic portable winch

1.0 SCOPE

1.1 Scope

This specification describes an electric or electrohydraulic winch specifically designed to deploy, cycle and recover a conductivity, temperature, depth (CTD) or a triaxial current profiler with CTD capability (VCTD) and having the capability of providing active compensation for ship motion. The winch speed and direction shall be remotely controlled by use of an analog voltage signal or a digital signal in IEEE 488 bus format.

2.0 APPLICABLE DOCUMENTS

2.1 Issues Of Documents

The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this specification to the extent specified herein.

MILITARY STANDARDS

MIL-STD-275	Printed Wiring for Electronic Equipment.
MIL-STD-454	Standard General Requirements for Electronic Equipment.

(Copies of specifications and standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications

The following documents form a part of this specificiation to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or request for proposal shall apply.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA Standards

(Application for copies should be addressed to the American Gear Manufacturers Association, 1330 Massachusetts Ave., N.W., Washington, D.C. 20005)

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION (AFBMA)

AFBMA Standards

(Application for copies should be addressed to the Anti-friciton Bearing Manufacturers Association, 2341 Jeff Davis Highway, Suite 1015, Century Building, Arlington, VA 22202).

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE Standard 488-1978,
"IEEE Standard Digital Interface for Programmable Instrumentation"

(Application for copies should be addressed to the Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, NY.

NATIONAL BUREAU OF STANDARDS

Handbook H28 Screw-Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Govenment Printing Office, Washington, D.C. 20402).

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3.0 REQUIREMENTS

3.1 General

3.1.1 Operational Location. - The winch shall be designed and constructed for installation of the weather deck of AGS or AGOR class ships which is unprotected from the marine environment. Design considerations shall be given to ensure that components do not become inoperative due to exposure to severe corrosive conditions and freezing temperatures.

3.1.2 Major Components. - The winch shall be electrically or electro-hydraulically driven and shall have the following minimum characteristics: electric motor, self-actuating brake, manual brake,

removable cable drum, slip-ring assemble, level wind device, line metering device, frame or bedplate, remote control unit, electrical cabling and connectors, protective fabric cover and all accessories necessary for independent operation as specified herein.

3.1.3 Power. - The winch shall operate solely on 440(+/- 40) VAC, 60(+/- 3) hertz, three phase, delta-connected ship's power. A main power switch and ciruit breaker protection shall be provided.

3.1.4 Packaging. - All winch components except the controls shall be contained on a single support frame. A separate unit shall house the winch controls. This remote unit shall be connected to the winch via a single electrical cable.

3.1.5 Weight And Dimensions. - The total weight of the winch excluding the electromechanical oceanographic cable and the remote control unit shall not exceed 4000 pounds. The winch shall fit within a 6 foot square area and shall not exceed six feet in height. The remote control unit shall not exceed 50 pounds. It shall be designed for rack mounting on a standard 19 inch relay rack and shall not exceed 6 inches in height.

3.2 Operational Requirements

3.2.1 Manual Operation - The winch shall power hoist and lower the VCTD package in a manual control mode. The manual control system shall be separate from the remote control system and shall have the capability of overriding the remote control system. The manual control system shall include a control lever that will cause line payout when the lever is moved away from the operator and line retrieval when the lever is moved toward the operator. Upon release, the lever will automatically return to the neutral position. The operator shall have a positive indication, by feel, when the lever is in the neutral position. Line payout and retrieval speeds shall be linearly proportional to the control lever displacement from neutral. The manual control shall have a control switch to enable either manual or remote operation. Remote operation shall be initiated only by means of this switch. A safety interlock shall allow startup of the electric motor only when the control lever is in the neutral position and the manual/remote switch is in the manual mode.

3.2.2 Remote Operation - A remote control unit shall be provided which will allow control of the winch from a location other than the near vicinity of the winch. This unit shall accept as a control input, an analog signal between -15 and +15 VDC or a digital siginal in IEEE 488 bus format. The direction and speed of payout or retrieval shall be controlled through this signal. If a digital signal is used, the speed must vary smoothly when the signal level changes.

3.3 Interface Requirements

The following information describes equipment and material owned by the government and does not form a part of this specification. This information is provided to aid the contractor in designing hardware that will properly interface with the existing system components.

3.3.1 Single Conductor Armored Cable. - The elctro-mechanical sea cable that will be used with the winch is type 1-H-255 as manufactured by the Rochester Corporation, Culpepper, VA. This cable has the following mechnical properties:

Outside Diameter:	0.254 inch.
Breaking Strength:	5600 pounds.
Weight in air:	112 pounds/1000 feet.
Weight in sea water:	90 pounds/1000 feet.
Conductor:	20 AWG, 7 Strand.
Insulation:	0.040 inch polypropylene.
Inner armor:	18 strands, 0.0245 inch diameter.
Outer armor:	18 strands, 0.035 inch diameter.
Minimum Bend Radius:	7 inches.

3.4 Performance Requirements.

3.4.1 Speed. - The winch shall be capable of raising and lowering the package at all speeds between -80 and +80 meters/minute. The speed shall be controlled by either an analog voltage signal between -15 and +15 volts, D.C. or a digital signal conforming to the IEEE 488 bus standard. The speed shall be controllable to within 0.5 centimeter/second. The speed of the winch shall be a linear function of the input signal to within 0.3% of full scale.

3.4.2 Acceleration. - The winch shall be capable, within the speed limitations given above, of providing up to at least 0.2 g acceleration of the VTCD package and wire at any layer and load, as herein specified.

3.4.3 Rated Load - The winch at mid-drum layer shall power hoist and lower a rated load of 1500 pounds. This load represents the static load of the VCTD instrument and the 1-H-255 sea cable as well as the dynamic load due to cable and instrument drag and inertial forces from the ship's motion. The winch shall payout and retrieve all loads up to and including the rated load at lines speeds from 0 to 80 meters per minute. It shall be capable of hoisting and lowering 150 percent of the rated load at no specific speed.

3.4.4 Duty. - The winch shall be capable of both intermittant operation and continuous operation up to 72 hours without overheating or component degradation beyond safe operating limits.

3.4.5 Environmental Conditions. - The winch will be exposed to a hostile marine environment that will include arctic and tropical conditions. It shall operate in accordance with this specification under the conditions described below. Performance shall not be degraded due to continuous exposure to this environment.

Ambient Temperature	:	-20 F to 110 F
Vibration	:	1 g at 4 to 50 hertz
Inclination	:	30 degrees from horizontal in all directions.
Moisture	:	drenchings from wind-driven spray and high seas; relative hunidity 0-100%
Salt fog	:	continuous exposure
Wind	:	up to 40 knots

The winch remote control unit will be protected from saltwater drenchings and shall operate at temperatures between 0 F and 100 F. The vibration, inclination, salt fog and relative humidity requirements listed above shall apply to the remote control unit.

3.4.6 Reliability - The design life of the winch system shall be at least 10000 operating hours with normal preventative maintenance procedures. The winch shall operate for a minimum of 1000 hours between minor overhauls without adjustments or parts replacement.

3.4.7 Noise - The winch shall have an overall noise level no greater than 90 dbA at a distance of 5 feet from it in any horizontal direction and at a height of 5 feet above the winch/deck interface when operating at the loads and speeds specified above.

3.5 Component Requirements.

All components shall be designed such that the winch system shall meet the operational and performance requirements as described above.

3.5.1 Electric Motor - An electric motor shall be utilized as the system prime mover. It shall operate on 440 (+/- 40) VAC, 60 (+/- 3) hertz, three phase, delta connected ship's power. It shall be housed in a watertight enclosure and shall be cooled as necessary. The armature shaft shall be anti-friction bearing mounted. Readily accessible grease fittings shall be provided for lubrication of the bearings. A thermal protection device which senses winding overheating and shuts off the motor shall be included.

3.5.2 Hydraulic Components. - If electro-hydraulic drive is utilized, the components of the hydraulic system shall meet the following requirements.

3.5.2.1 Fluid Reservoir. - The hydraulic fluid reservoir shall be designed for easy maintenance. The tank bottom shall be sloped or dished with the drain at the lowest point to permit complete draining of all fluid. The drain shall be readily accessible and positioned to allow draining without spillage on the winch components or frame. One or more easily accessible covers shall be provided for cleaning and and maintenance. The reservoir filler hole shall have a replaceable fine mesh screen filter to minimize fluid contamination during replenishment. A sight glass fluid level gage shall be provided to indicate normal, high or low fluid levels. The reservoir air breather shall be fitted with a replaceable filter capable of excluding the marine atmosphere. A baffle shall be included in the reservoir and shall separate the pump inlet line from returns lines such that the same fluid cannot recirculate continuously without significant mixing. To permit cold weather operation, an automatically controlled heater shall be proved that is capable of maintaining a minimum fluid temperature of 60 F when the ambient temperature is -20 F and the winch is exposed to 40 knot winds. A temperature gage that indicated fluid temperature shall be mounted on the reservoir in a highly visible location. This gage shall have a minimum range from -20F to

200 F and shall have an accuracy of at least 5 F. Under conditions of continuous duty and maximum ambient temperature, the fluid in the reservoir shall not exceed a temperature of 150 F. If neceesary, an automatically activated heat exchanger system shall be provided to limit fluid temperature.

3.5.2.2 Pressure Gage. - A pressure gage shall be provided to indicate the hydraulic pump output pressure. The gage shall have a minimum accuracy of 5% of the rated operating pressure with a minimum resolution of 5% of the rated operating pressure. It shall indicate pressures from 0 to 125% of the rated operating pressure. The gage shall be readily visible from a standing position (when standing in back of the winch).

3.5.2.3 Relief Valve. - An adjustable relief valve shall be provided in the high pressure circuit to limit maximum system pressure. The relief valve shall have a volumetric capacity not less than the full displacement of the hydraulic pump.

3.5.2.4 Air Vents. - Air vents shall be provided at all points in the hydraulic system where air will tend to accumulate and may result in unsatifactory operation. Disconnection of fluid lines is not an acceptable method of venting air.

3.5.2.5 Filter - A 10 micron full flow replaceable cartridge type filter shall be provided in an easily accessible location in the suction line between the reservoir and the hydraulic pump.

3.5.2.6 Fluid Connections. - All hydraulic lines and fittings shall conform to commercial hydraulic industry standards. A minimum safety factor of 8 shall be used in sizing pipe and tubing. All connections shall be leakproof under operating maximum pressure. Hydraulic system components shall have straight thread or flange connections with "O"-ring seals. Tapered pipe threads shall not be used except for pressure gage and drain line connections. Lines shall be properly supported with damping mounts to minimize loosening of connections due to shock and vibration. All fittings and tubing shall be of corrosion resistant material.

3.5.3 Self Actuating Brake - An electrically or hydraulically released, spring-setting brake shall be provided to stop the winch drum. The brake shall automatically release when the manual control lever is moved from the neutral position or when automatic cycling is initiated. The brake shall set automatically when the control lever is returned to the neutral position, when automatic cycling is stopped, when the system alarm sounds or when there is a loss of electrical or hydraulic power. In the remote control mode, the brake should not set and release during direction reversal. The brake shall be designed to stop a load of 2250 pounds at mid-drum layer when lowering at 80 meters/minute. Braking action shall be smooth and the drum shall come to a complete stop within 3 seconds of brake engagement. The dsign shall allow a static pull of 3000 pounds at mid-drum layer without slippage.

3.5.4 Manual Brake. - The winch shall be provided with a manually applied brake that is separate and distinct from the self-acuating brake. The manual brake shall stop a load of 2250 pounds at mid-drum layer when lowering at 80 meters/minute and shall hold a static load of 3000 pounds without slippage at mid-drum layer. The hand wheel or lever used to set the manual brake shall be readily accessible and clear of the cable drum and level wind device to afford maximum safety to operating personnel.

3.5.5 Cable Drum - The winch drum shall have a capacity for 4000 meters of 1-H-255 cable. At least on inch of flange shall remain uncovered when this length of cable is fully wound on the drum. The drum core and flanges shall have sufficient strength to withstand forces (no permanent set) due to cable contraction and expansion caused by temperature changes or self-loading during deployment. The drum shall be easily removed and installed. It shall have provisions for bringing the cable end from the inner wrap to the slip ring assembly. A grooved drum may be used; however, provisions shall be made for easy removal of the grooves to permit use of the drum for other cable diameters.

3.5.6 Slip Ring Assembly - A slip ring assembly with a minimum of two circuits shall be used to provide electrical continuity between the 1-H-255 sea cable and the data terminal on the ship. It shall have the following characteristics:

Voltage rating: 200 VDC minimum
Current rating: 2 amps minimum
Resistance : 0.1 ohm maximum
Noise : 100 microvolts maximum at 2 to 18 KHz.

3.5.7 Level Wind Device. - A power operated level wind device capable of smoothly laying the 1-H-255 cable onto the drum shall be provided. It shall accomodate cable leads from 10 degrees below the horizontal to 30 degrees above. Additionally, it shall accept cable from 30 degrees to either side of a line perpendicular to the drum axis. Provisions shall be made to permit disengagement of the level wind power drive and allow manual spooling of the line. A means to easily adapt the level wind device to other cable cable diameters shall be provided.

3.5.8 Line Metering Device. - A means to measure the amount and rate of cable payout and retrieval shall be provided. The amount shall be measured to an accuracy of +/- 10 meters or 1% of the amount out, whichever is greater. The rate shall be determined to better than +/- 1 meter/min.

3.5.9 Frame. - A single frame or bedplate of welded construction shall support the winch components. Provisions shall be made to allow the frame to be bolted to the deck of AGS and AGOR class ships without special modifications or additions to the frame. Frame design shall avoid pockets where water can stand or collect. Lifting eyes shall be provided such that the winch can be easily and safely moved. Tie down points shall be provided for securing the protective fabric cover.

3.5.10 Gearing. - If gear drive is used (as opposed to direct motor drive) on the winch drum, the gearing shall be in accordance with the American Gear Manufacturers Association (AGMA) publications. Design consideration shall be given to loads and speeds in the selection of gear types and sizes. Gears which exhibit smooth, quiet operation, such as helical gears shall be used. All gearing shall be enclosed in an oil-tight case and lubricated by an oil bath. The case shall have a drain plug that will permit complete draining. A means to easily check the oil level shall be provided.

3.5.11 Bearings. - Ball or roller bearings shall be used on gear and drum shafts and on all accessory mechanisms that rotate continuously during winch operation. All bearing shall conform to Anit-Friction Bearing Manufacturers Association (AFBMA) standards. Loading, speed, lubrication, and service life shall be considered in the selection of bearing types and classes. Exposed bearings shall be sealed to exclude contaminants and salt spray and to retain lubricant. Corrosion resistant grease fittings shall be provided in easily accessible locations.

3.5.12 Manual Control Unit - The manual control unit shall contain such switches, readouts, controls, and electronic circuitry necessary for complete manual control of the winch. As a minimum, the following features shall be included:

(a) Winch on/off switch This shall start and stop the electric motor, provided the control lever is in neutral and the remote/manual switch is in the manual mode.

(b) Manual control lever This shall permit manual operation of the winch whenever the remote/manual switch is in the manual mode.

(c) Remote/manual switch This shall control whether the winch operates in a manual mode or is controlled by the remote control unit.

(d) Line out read-out This shall display, in meters, the total amount of cable payed out. Resolution shall be to the nearest meter. The display should be easily readable in daylight or night. A manual reset shall be provided to zero the readout.

(e) Line speed readout This shall display the rate of line payout or retrieval in meters per minute. An indication whether the cable in paying out or coming in shall be provided. Resolution shall be to the nearest meter per minute. The readout shall be easily readable in daylight or night.

(f) Audible alarm The remote control unit shall sound an audible alarm and shall cause the self acuating brake to engage whenever the cable speed is greater than 100 meters/minute .

3.5.13 Remote Control Unit - The remote control unit shall contain such switches, controls, electronics and connectors as necessary to permit remote operation of the winch when the remote/manual switch on the manual control unit is in the remote mode. The remote control unit must contain as a minimum, the following features:

(a) Control connector If the control be analog, this shall consist of a BNC RG58U female connector. If the control is to be digital in IEEE 488 bus format, the connector shall be the standard IEEE 488 bus female connector, compatible with a Hewlett-Packard model 10833A connector.

(b) Remote indicator This shall indicate whether the remote or the manual unit is enabled. Such indicator shall be easily visible in day or night conditions and shall be controlled solely by the manual control unit remote/manual switch.

(c) Manual operation switch This shall provide a means by which control may be switched from remote to manual operation from the remote unit. It shall not be capable of enabling remote operation once manual operation is selected. When control is

passed to the manual controller by means of this switch, the manual speed lever shall be automatically set to neutral, after which the manual control may be exercised.

3.5.14 Fasteners. - All threaded fasteners, including set screws, shall be locked to prevent loosening due to vibration. Externally located fasteners shall be of corrosion resistant material. Threads shall be unified fine or coarse (UNF) or (UNC) thread series in accordance with National Bureau of Standards Handbook H28.

3.5.15 Electrical Connections - Watertight, corrosion resistant electrical connectors shall be provided wherever exposure to a hostile environment may be possible. All other electrical connections shall be made inside watertight enclosures or junction boxes. Connections for major components shall be readily accessible and easily disconnected to facilitate maintenance and repair.

3.5.16 Electrical Cables. - A power cable and a control cable shall be supplied with the winch. Both cables shall be of rugged construction suitable for exposure to weather and the marine environment. The power cable shall be at least 200 feet in length. The control cable shall be at least 200 feet in length.

3.5.17 Elapsed Time Meter. - A meter which indicates cumulative winch operating time in hours and tenths of hours shall be provided and mounted in an accessible location on the winch.

3.5.18 Protective Cover. - A waterproof coated fabric covershall be supplied with the winch. The fabric weight shall be not less than 15 ounces per square yard. The cover shall fit neatly over the winch and shall have some means for attachment to the winch frame. Points of high stress or excessive wear shall be reinforced.

3.6 Painting.

3.6.1 Ferrous Surfaces. – Before assembly, all ferrous surfaces not intended to be bright shall be cleaned by abrasive blasting to near white metal. One coat of Dimetcote 6 or Dimetcote 9 (manufactured by Ameron, Protective Coatings division, Brea, California) or an equivalent inorganic zinc rich primer shall be applied to the blasted areas. Dry film thickness shall be not less than 2.5 mils. After assembly, the exposed primed surfaces shall be coated with Amercoat 84 or Amercoat 383HHS (manufactured by Ameron) or an equivalent polyamide epoxy topcoat. This coating shall have a minimum dry film thickness of 4 mils.

3.6.2 Non-ferrous Surfaces – Before assembly, all non-ferrous surfaces shall be cleaned and lightly abraded. One coat of Amercoat 83 primer or equivalent shall be applied immediately to the abraded areas. Dry film thickness shall be not less than 2 mils. After assembly, a topcoat shall be aplied as in the previous section.

3.7 Safety.

Safety for operating and maintenance personnel shall be a consideration in the design and construction of the winch. When the equipment is properly installed and grounded, there shall be no accessible way for personnel to receive an electrical shock due to an internal fault or short. External projections and sharp corners which may cause injury in rough seas shall be avoided or properly safeguarded. Guards shall be provided on moving parts that are potentially hazardous.

3.8 Maintainability

The winch shall be designed for ease of maintenance. Time required to service the winch and cost of replacement parts shall be kept to a minimum. If special tools are required, they shall be supplied with and attached to the winch. Routine preventative maintenance procedures shall be easily performed aboard ship.

3.9 Materials.

All materials used shall be in accordance with either commercial or Government specifications. Part shall be compatible with each other and with the environment for which they are intended.

3.10 Workmanship.

Electrical components shall exhibit workmanship in accordance with MIL-STD-454, Requirement 9. Printed wiring shall conform to MIL-STD-275. Conformal coating is required on printed wiring assemblies. Internal hookup wire shall be selected and intentified in accordance with MIL-STD-454, requirement 20. Soldering shall meet the requirements specified in MIL-STD-454, requirement 5.

3.11 Documentation.

The following documents shall be prepared in the contractor's format:

(a) Mechnical Drawings. . These shall include all assembly drawings and parts lists used in fabricating the winch. All components shall be identified by manufacturer's name and part number. If electro-hydraulic control is utilized, a hydraulic circuit shall be prepared.

(b) Electrical drawings. These shall consist of schematics and wiring diagrams which depict all electrical and electronic components and interconnections. Assembly drawings showing component locations and complete parts lists shall be prepared.

3.12 Operation And Maintenance Manual.

An operation and maintenance manual shall be prepared and shall contain the following information as a minimum:

(a) Description of equipment
(b) Operating instructions.
(c) Maintenance program.
(d) Trouble-shooting procedures.
(e) Documentation list.
(f) Manufacturers' specifications for major components.

3.13 Recommended Spare Parts List.

A listing of recommended spare parts shall be prepared and delivered.

3.14 Test Plan And Test Report.

A test plan describing test setups and procedures to be used in quality conformance testing shall be submitted to the Naval Ocean Research and Development Activity, Code 331 for approval prior to running any tests. Code 331 shall be notified at least two weeks prior to testing in order to have a representative present during the manufacturer's testing of the winch. A test report giving the results of these tests shall be submitted to code 331.

4.0 QUALITY CONTROL PROVISIONS

4.1 Responsibility For Inspection.

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribe requirements.

4.2 Quality Conformance Inspection.

4.2.1 Visual Inspection. - The winch shall be visually examined to determine compliance with the requirements of this specification. Any non-conformance shall be cause for rejection.

4.2.2 Tests. - The winch shall be tested as specified in 4.3.1 through 4.3.4 to determine compliance with this specification. Any performance failures or shortcomings shall be cause for rejection of the winch.

4.3 Test Methods.

4.3.1 No Load Test. - The winch shall be operated without load at maximum drum speed for 30 minutes in each direction of rotation. No abnormal heating (150 F) of bearings or operating parts shall occur.

4.3.2 Rated Load Test. -

4.3.2.1 Rated Load Test - Manual Operation. - In the manual mode of operation, the winch shall payout and retrieve the rated load for at least 10 meters in each direction at a rate of 80 meters/minute. The load shall be stopped and held for approximately 20 seconds at the end of each half cycle. Cycling shall continue for a period of 30 minutes. The load shall be continuous throughout the test. No abnormal heating of any part shall occur.

4.3.2.2 Rated Load Test - Remote Operation - In the remote mode of operation, the winch shall payout and retrieve the rated load in each direction for at least 5.95 feet. The winch shall be controlled by an appropriate controller (either digital, utilizing, for example, a Hewlett-Packard 9825A desk-top calculator or analog). The winch shall be cycled with a sinusoidal signal providing a speed amplitude of 80 meters per minute with an acceleration amplitude of 0.2 g (1.96 meters/sec/sec), minimum. Cycling shall continue for a period of 60 minutes. The load shall be continuous throughout the test. The speed of payout shall be a linear function of the input control signal to within 0.5 centimeters per second. No abnormal heating (150 F) of any part shall occur. After 60 minutes, the manual override switch on the remote control unit shall be switched to manual operation. The winch shall stop automatically and manual control shall be verified in both directions.

4.3.3 Overload Test. - The winch shall payout and retrieve 150 percent the rated load at no specified speed through a distance of at least 20 feet in each direction for five complete cycles. The load shall be stopped and held for approximately 20 seconds at the end of each half cycle. The load shall be continuous throughout the test.

4.3.4 Brake Test. - The self-actuating brake and the manual brake shall be individually tested to demonstrate their ability to stop and hold 150 percent of the rated load when paying out at 80 meters/minute. Each brake shall be subjected to a static pull of 200 percent of the rated load and shall demonstrate no slippage.

5.0 PACKAGING

5.1 Packaging Requirements

Preservation-packaging and packing shall protect the equipment against corrosion, deterioration, and damage during shipment. Shipping container design and marking shall comply with applicable regulations as determined by the mode of transportation

6.0 NOTES

6.1 Data Requirements.

The data specified below shall be delivered by the contractor in accordance with the Contract Data Requirements List (DD Form 1423).

Paragraph	Data Requirements
3.11	Drawings
3.12	Operation and maintenance manual
3.13	Recommended spare parts list
3.14	Test Plan
3.14	Test Report

Appendix B: Computer code for Z-100 winch control

```
                                      PAGE    ,132
      0000                            FUNC    SEGMENT
                                      ASSUME  CS:FUNC
                                      PUBLIC CIC
                                      PUBLIC INIT
                                      PUBLIC CLBF
                                      PUBLIC RCV
                                      PUBLIC READGPIB
                                      PUBLIC DSEND
                                      PUBLIC WRITEGPIB
                                      PUBLIC CSEND
                                      PUBLIC CMD
                                      PUBLIC IFC
                                      PUBLIC PASS
                                      PUBLIC GPIBTIME
                      C               INCLUDE MACLIB.ASM
                      C
                      C
                      C  ;       MACLIB - library of commonly used macro definitions
                      C
                      C  SVC     MACRO   DOSF                      ;Supervisor (DOS function) call
                      C          MOV     AH,DOSF
                      C          INT     21H
                      C          ENDM
                      C
                      C  RETF    MACRO                             ;Return far instruction emulation
                      C          LOCAL   TEMP1
                      C  TEMP1   PROC    FAR
                      C          RET
                      C  TEMP1   ENDP
                      C          ENDM
                      C
                      C  PUSHALL MACRO                             ;Save all registers
                      C          PUSH    AX
                      C          PUSH    BX
                      C          PUSH    CX
                      C          PUSH    DX
                      C          PUSH    SI
                      C          PUSH    DI
                      C          PUSH    BP
                      C          PUSH    DS
                      C          PUSH    ES
                      C          ENDM
                      C
                      C  POPALL  MACRO                             ;Restore all registers
                      C          POP     ES
                      C          POP     DS
                      C          POP     BP
                      C          POP     DI
                      C          POP     SI
                      C          POP     DX
                      C          POP     CX
                      C          POP     BX
                      C          POP     AX
                      C          ENDM
                      C
                      C  ERRNZ   MACRO   LABEL,ADDRESS             ;Check current location
                      C     IF   (($-OFFSET LABEL)-ADDRESS NE 0)
                      C  #1:     DW      LABEL,ADDRESS
                      C     ENDIF
                      C          ENDM
                      C
                      C  ERRZR   MACRO   LABEL,ADDRESS             ;Error if zero
                      C     IF   (($-OFFSET LABEL)-ADDRESS EQ 0)
```

```
         C  #1:     DW        LABEL,ADDRESS
         C     ENDIF
         C          ENDM
         C
         C                    INCLUDE DEFGPIB.ASM
         C      ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
         C      ;                                                                          ;
         C      ;                DEFINITIONS FOR GPIB DRIVER                               ;
         C      ;                                                                          ;
         C      ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
         C
         C  ;
         C  ;
         C  ;
         C  ;
         C  ;       CODE                               COMMENTS
         C  ;-------------------------------------------------------------------------------
         C  ;
= 0040   C          BASE    EQU     40H       ; BASE ADDRESS OF GPIB-696 INTFC
= 0040   C          DIR     EQU     BASE+0    ; DAT IN REGISTER
= 0040   C          CDOR    EQU     BASE+0    ; CONTROL/DATA OUT REGISTER
= 0041   C          ISR1    EQU     BASE+1    ; INTERRUPT STATUS REGISTER 1
= 0041   C          IMR1    EQU     BASE+1    ; INTERRUPT MASK REGISTER 1
= 0042   C          ISR2    EQU     BASE+2    ; INTERRUPT STATUS REGISTER 2
= 0042   C          IMR2    EQU     BASE+2    ; INTERRUPT MASK REGISTER 2
= 0043   C          SPSR    EQU     BASE+3    ; SERIAL POLL STATUS REGISTER
= 0043   C          SPMR    EQU     BASE+3    ; SERIAL POLL MASK REGISTER
= 0044   C          ADSR    EQU     BASE+4    ; ADDRESS STATUS REGISTER
= 0044   C          ADMR    EQU     BASE+4    ; ADDRESS MODE REISTER(WRITE)
= 0045   C          CPTR    EQU     BASE+5    ; COMMAND PASSTHRU REGISTER
= 0045   C          AUXMR   EQU     BASE+5    ; AUXILIARY MODE REGISTER
= 0046   C          ADR0    EQU     BASE+6    ; ADDRESS REG. 0 (READ)
= 0046   C          ADR     EQU     BASE+6    ; ADDRESS REGISTER (WRITE)
= 0047   C          ADR1    EQU     BASE+7    ; ADDRESS REGISTER 1
= 0047   C          EOSR    EQU     BASE+7    ; END OF STRING REGISTER (WRITE)
         C  ;
         C  ;
         C  ;                    ISR1 BITS
         C  ;
         C  ;
         C  ;
= 0001   C          DATI    EQU     01H       ; DATA IN
= 0002   C          DO      EQU     02H       ; DATA OUT
= 0004   C          ERR     EQU     04H       ; ERROR
= 0010   C          ENDRX   EQU     10H       ; END RECEIVED
         C  ;
         C  ;
         C  ;                    ISR2 BITS
         C  ;
         C  ;
= 0008   C          CO      EQU     08H       ; COMMAND OUT
         C  ;
         C  ;
         C  ;                    ADR1 BITS
         C  ;
         C  ;
= 0080   C          EOI     EQU     80H
= 0040   C          DT1     EQU     40H
= 0020   C          DL1     EQU     20H
         C  ;
         C  ;
         C  ;                   ADSR BITS
         C  ;
         C  ;
= 0040   C          NATN    EQU     40H       ; NOT ATN
```

```
                   C  ;
                   C  ;            ADMR BITS
                   C  ;
                   C  ;
                   C  ;
= 0001             C  MODE1   EQU    01H      ; ADDRESS MODE 1
= 0030             C  TRM     EQU    30H      ; GPIB FCTS FOR T/R2 AND T/R3
                   C  ;
                   C  ;
                   C  ;            AUXMR HIDDEN REGISTERS
                   C  ;
                   C  ;
= 0020             C  ICR     EQU    20H      ; INTERNAL COUNTER REGISTER
= 0060             C  PPR     EQU    60H      ; PARALLEL POLL REGISTER
= 0080             C  AUXRA   EQU    80H      ; AUX REG A
= 00A0             C  AUXRB   EQU    0A0H     ; AUX REG B
= 00C0             C  AUXRE   EQU    0C0H     ; AUX REG E
                   C  ;
                   C  ;
                   C  ;            AUXMR COMMANDS
                   C  ;
                   C  ;
= 0000             C  IEPON   EQU    000Q     ; IMMEDIATE EXECUTE POWER ON
= 0003             C  FH      EQU    003Q     ; FINISH ( RELEASE ) HANDSHAKE
= 0006             C  SEOI    EQU    006Q     ; SEND END
= 0010             C  GTS     EQU    020Q     ; GO TO STANDBY
= 0011             C  TCA     EQU    021Q     ; TAKE CONTROL ASYNCHRONOUSLY
= 0012             C  TCS     EQU    022Q     ; TAKE CONTROL SYNCHRONOUSLY
= 001A             C  TCSE    EQU    032Q     ; TAKE CNTL SYNC. ON END
= 0013             C  LTN     EQU    023Q     ; LISTEN
= 001B             C  LTNC    EQU    033Q     ; LISTEN CONTINUOUSLY
= 001C             C  LUN     EQU    034Q     ; UNLISTEN
= 001E             C  SIFC    EQU    036Q     , SET IFC
= 0016             C  CIFC    EQU    026Q     , CLEAR IFC
= 001F             C  SREN    EQU    037Q     , SET REN
= 0017             C  CREN    EQU    027Q   . , CLEAR REN
                   C  .
                   C  ;
                   C  .            GPIB COMMANDS
                   C  .
                   C  .
= 0009             C  TCT     EQU    011Q     ; TAKE CONTROL
= 003F             C  UNL     EQU    077Q     ; UNIVERAL UNLISTEN
= 005F             C  UNT     EQU    137Q     ; UNIVERAL UNTALK
                   C  ;
                   C  ;
                   C  ;            USER SPECIFIED COMMANDS
                   C  ;
                   C  ;
= 0000             C  SEL0    EQU    0        ; SELECT ADR0
= 0080             C  SEL1    EQU    200Q     ; SELECT ADR1
= 0000             C  MA      EQU    0        ; GPIB ADDRESS OF GPIB-696 = 0
= 0010             C  SC      EQU    020Q     ; SYSTEM CONTROLLER
                   C  ;
                   C  ;
                   C  ;            PROGRAM VARIABLES/BUFFERS
                   C  ;
                   C  ;
0000  00           C  CIC     DB     0        ; CIC FLAG
0001  0000         C  T1      DW     0        ; CX REGISTER FOR TIME
0003  0000         C  T2      DW     0        ; DX REGISTER FOR TIME
0005     64 [      C  CMDBUF  DB   100 DUP(0FFH)  ; COMMAND BUFFER FOR INTRFC MSGS
            FF     C
               ]   C
                   C
```

```
0069  00                  C           CMDCT   DB      0       ; NUMBER OF COMMANDS TO BE SENT
006A  00                  C           COUNT   DB      0       ; NUMBER OF CURRENT CMDS XFERED
006B     64 [             C           DATBUF  DB  100 DUP(OFFH)  ; DATA BUFFER
              FF          C
                  ]       C
                          C
00CF  0000                C           DATCT   DW      0       ; NUMBER OF DATA BYTES TO BE SENT
00D1  36                  C           OLA     DB      54      ; LISTEN ADDRESS PASSED TO WRITE
00D2  00                  C           SRE     DB      0       ; REN FLAG ( NOT 0 SETS REN )
00D3  00                  C           TCTADR  DB      0       ; TCT ADDRESS OF NEW ACTIVE CONTROLLER
00D4  00                  C           VSEOI   DB      0       ; SEOI FLAG ( NON 0 TO SEND END MSG
                          C                                   ; WITH LAST DSEND BYTE )
00D5  0200 [              C           DUMMY   DB 512 DUP(00H) ; DUMMY SPACE
              00          C
                  ]       C
                          C
                          C
                          C                   INCLUDE INITGPIB.ASM
                          C    ;
                          C    ;
                          C    ;      ****************************************
                          C    ;      *                                      *
                          C    ;      *    INITIALIZE      -      INIT       *
                          C    ;      *                                      *
                          C    ;      ****************************************
                          C    ;
                          C    ;
                          C    ;
                          C    ;
                          C    ;      THE DETAILED COMMENTS FOR THIS CODE HAVE NOT
                          C    ;      BEEN INCLUDED  THEY MAY BE FOUND IN THE LISTING
                          C    ;      ON PAGES B-6 AND B-7 OF THE GPIB-696 REF.  MANUAL
                          C    ;
                          C    ;
                          C    ;
02D5                      C    INIT   PROC    FAR
02D5  B0 02               C           MOV     AL,02Q
02D7  E6 45               C           OUT     AUXMR,AL
02D9  E4 41               C           IN      AL,ISR1
02DB  E4 42               C           IN      AL,ISR2
02DD  E4 45               C           IN      AL,CPTR
02DF  B0 00               C           MOV     AL,0
02E1  E6 43               C           OUT     SPMR,AL
02E3  E6 41               C           OUT     IMR1,AL
02E5  E6 42               C           OUT     IMR2,AL
02E7  B0 31               C           MOV     AL,MODE1+TRM
02E9  E6 44               C           OUT     ADMR,AL
02EB  B0 00               C           MOV     AL,MA+SEL0
02ED  E6 46               C           OUT     ADR,AL
02EF  B0 E0               C           MOV     AL,DT1+DL1+SEL1
02F1  E6 46               C           OUT     ADR,AL
02F3  B0 25               C           MOV     AL,ICR+5
02F5  E6 45               C           OUT     AUXMR,AL
02F7  B0 80               C           MOV     AL,AUXRA
02F9  E6 45               C           OUT     AUXMR,AL
02FB  B0 A0               C           MOV     AL,AUXRB
02FD  E6 45               C           OUT     AUXMR,AL
02FF  B0 C0               C           MOV     AL,AUXRE
0301  E6 45               C           OUT     AUXMR,AL
0303  B0 70               C           MOV     AL,160Q
0305  E6 45               C           OUT     AUXMR,AL
0307  B0 00               C           MOV     AL,IEPON
0309  E6 45               C           OUT     AUXMR,AL
030B  CB                  C           RET
```

```
030C                           C  INIT     ENDP
                               C
                               C                    INCLUDE CSENDGPI.ASM
                               C  ;
                               C  ;
                               C  ;        ***********************************************
                               C  ;        *                                             *
                               C  ;        *       COMMAND SEND    - CSEND               *
                               C  ;        *                                             *
                               C  ;        ***********************************************
                               C  ;
                               C  ;
                               C  ;
                               C  ;        COMMENTS HAVE BEEN LEFT OUT  THEY MAY BE FOUND
                               C  ;        ON PAGE B-18 OF GPIB-696 MANUAL
                               C  ;
                               C  ;
030C                           C  CSEND    PROC     FAR
030C  2E: C6 06 006A R 00      C           MOV      COUNT,0
0312  2E: A0 006A R            C  CSEND4:  MOV      AL,COUNT
0316  3A C3                    C           CMP      AL,BL
0318  74 1B                    C           JZ       CSEND3
031A  E4 42                    C  CSEND1:  IN       AL,ISR2
031C  24 08                    C           AND      AL,CO
031E  74 FA                    C           JZ       CSEND1
0320  2E: FE 06 006A R         C           INC      COUNT
0325  2E: 8A 04                C           MOV      AL,BYTE PTR CS:[SI]
0328  E6 40                    C           OUT      CDOR,AL
032A  E4 41                    C           IN       AL,ISR1
032C  24 04                    C           AND      AL,ERR
032E  75 03                    C           JNZ      CSEND2
0330  46                       C           INC      SI
0331  EB DF                    C           JMP      CSEND4
0333  B3 FF                    C  CSEND2:  MOV      BL,377Q
0335  CB                       C  CSEND3:  RET
0336                           C  CSEND    ENDP
                               C
                               C                    INCLUDE CMDGPIB.ASM
                               C  ;
                               C  ;
                               C  ;        ***********************************************
                               C  ;        *                                             *
                               C  ;        *       COMMAND         -      CMD            *
                               C  ;        *                                             *
                               C  ;        ***********************************************
                               C  ;
                               C  ;
                               C  ;
                               C  ;
                               C  ;
                               C  ;        THE COMMENTS FOR THIS CODE MAY BE FOUND ON PAGES
                               C  ;        B-19 OF THE GPIB-696 MANUAL.
                               C  ;
                               C  ;
                               C  ;
0336                           C  CMD      PROC     FAR
0336  B0 11                    C           MOV      AL,TCA
0338  E6 45                    C           OUT      AUXMR,AL
033A  BE 0005 R                C           MOV      SI, OFFSET CMDBUF
033D  2E: 8A 1E 0069 R         C           MOV      BL, CMDCT
0342  9A 030C ---- R           C           CALL     CSEND
0347  CB                       C           RET
0348                           C  CMD      ENDP
                               C
                               C                    INCLUDE IFCGPIB.ASM
```

```
                      C ;
                      C ;
                      C ;     *****************************************************
                      C ;     *                                                   *
                      C ;     *                        IFC                        *
                      C ;     *                                                   *
                      C ;     *****************************************************
                      C ;
                      C ;
0348                  C IFC     PROC    FAR
0348  B0 1E           C         MOV     AL,SIFC
034A  E6 45           C         OUT     AUXMR,AL
034C  B9 012C         C         MOV     CX,300
034F  E2 FE           C IFC1    LOOP    IFC1
0351  B0 16           C         MOV     AL,CIFC
0353  E6 45           C         OUT     AUXMR,AL
0355  CB              C         RET
0356                  C IFC     ENDP
                      C
                      C                 INCLUDE RCVGPIB.ASM
                      C ;
                      C ;
                      C ;     ****************************************
                      C ;     *                                      *
                      C ;     *          RECEIVE      -RCV           *
                      C ;     *                                      *
                      C ;     ****************************************
                      C ;
                      C ;
                      C ;     COMMENTS ON PAGES B-10 AND B-11 OF MANUAL
                      C ;
0356  00              C ERRCNT  DB      0
0357                  C RCV     PROC    FAR
0357  B0 10           C         MOV     AL,20Q
0359  E6 45           C         OUT     AUXMR,AL
035B  B9 0000         C         MOV     CX,0
035E  2E: C6 06 0356 R 00 C     MOV     ERRCNT,0
0364  E4 41           C RCV3:   IN      AL,ISR1
0366  24 11           C         AND     AL,ENDRX+DATI
0368  75 0F           C         JNZ     NEXT
                      C ;       IN;     AL,DIR
036A  2E: FE 06 0356 R C        INC     ERRCNT
036F  2E: A0 0356 R   C         MOV     AL,ERRCNT
0373  3C 32           C         CMP     AL,50
0375  74 1D           C         JE      RCV6
0377  EB EB           C         JMP     RCV3
0379  2E: C6 06 0356 R 00 C NEXT: MOV   ERRCNT,0
037F  E4 40           C         IN      AL,DIR
0381  2E: 88 05       C         MOV     BYTE PTR CS:[DI],AL
0384  47              C         INC     DI
0385  41              C         INC     CX
0386  3B D9           C         CMP     BX,CX
0388  75 DA           C         JNZ     RCV3
038A  EB 08 90        C         JMP     RCV6
038D  E4 40           C RCV5    IN      AL,DIR
038F  2E: 88 05       C         MOV     BYTE PTR CS:[DI],AL
0392  8B D9           C         MOV     BX,CX
0394  90              C RCV6    NOP
0395  CB              C         RET
0396                  C RCV     ENDP
                      C
                      C                 INCLUDE READGPIB.ASM
                      C ;
                      C ;
```

```
                                C ;            *************************************
                                C ,            *                                   *
                                C ;            *             READGPIB              *
                                C ;            *                                   *
                                C ;            *************************************
                                C ;
                                C ;
      0396                      C READGPIB          PROC    FAR
      0396  FA                  C              CLI
      0397  B0 00               C              MOV      AL, 0
      0399  E6 45               C              OUT      AUXMR, AL
      039B  9A 0348 ---- R      C              CALL  IFC
      03A0  B9 01F4             C              MOV      CX, 500
      03A3  E2 FE               C XLOOP:       LOOP     XLOOP
      03A5  2E: A0 0005 R       C              MOV      AL, CMDBUF
      03A9  2E: A2 0007 R       C              MOV      CMDBUF+2, AL
      03AD  B0 5F               C              MOV      AL, UNT
      03AF  2E: A2 0005 R       C              MOV      CMDBUF, AL
      03B3  B0 3F               C              MOV      AL, UNL
      03B5  2E: A2 0006 R       C              MOV      CMDBUF+1, AL
      03B9  B0 20               C              MOV      AL, 40Q
      03BB  2E: A2 0008 R       C              MOV      CMDBUF+3, AL
      03BF  2E: A0 0069 R       C              MOV      AL, CMDCT
      03C3  04 03               C              ADD      AL, 3
      03C5  2E: A2 0069 R       C              MOV      CMDCT, AL
      03C9  9A 0336 ---- R      C              CALL     CMD
      03CE  B0 10               C              MOV      AL, GTS
      03D0  E6 45               C              OUT      AUXMR, AL
      03D2  2E: 8B 1E 00CF R    C              MOV      BX, DATCT
      03D7  BF 006B R           C              MOV      DI,  OFFSET DATBUF
      03DA  9A 0357 ---- R      C              CALL     RCV
      03DF  B0 11               C              MOV      AL, TCA
      03E1  E6 45               C              OUT      AUXMR, AL
      03E3  FB                  C              STI
      03E4  CB                  C              RET
      03E5                      C READGPIB          ENDP
                                C
                                C                   INCLUDE DSENDGPI.ASM
                                C ;
                                C ;
                                C ;            *************************************
                                C ;            *                                   *
                                C ,            *   DATA SEND       -     DSEND     *
                                C ,            *                                   *
                                C ,            *************************************
                                C ;
                                C ;
                                C ;
      03E5                      C DSEND        PROC     FAR
      03E5  8B CB               C              MOV      CX, BX
      03E7  E4 41               C DSEND1:      IN       AL, ISR1
      03E9  24 06               C              AND      AL, DO+ERR
      03EB  74 FA               C              JZ       DSEND1
      03ED  24 04               C              AND      AL, ERR
      03EF  75 19               C              JNZ      DSEND3
      03F1  49                  C              DEC      CX
      03F2  7C 19               C              JL       DSEND4
      03F4  75 0C               C              JNZ      DSEND2
      03F6  2E: 80 3E 00D4 R 00 C              CMP      VSEOI, 0
      03FC  74 04               C              JZ       DSEND2
      03FE  B0 06               C              MOV      AL, SEOI
      0400  E6 45               C              OUT      AUXMR, AL
      0402  2E: 8A 04           C DSEND2:      MOV      AL,  BYTE PTR CS:[SI]
      0405  E6 40               C              OUT      CDOR, AL
```

```
0407  46                        C            INC      SI
0408  EB DD                     C            JMP      DSEND1
040A  BB FFFF                   C  DSEND3:   MOV      BX,177777Q
040D  CB                        C  DSEND4:   RET
040E                            C  DSEND     ENDP
                                C
                                C                     INCLUDE WRITEGPI.ASM
                                C  ;
                                C  ;
                                C  ;         ***************************************
                                C  ;         *                                     *
                                C  ;         *              WRITEGPIB              *
                                C  ;         *                                     *
                                C  ;         ***************************************
                                C  ;
                                C  ;
040E                            C  WRITEGPIB          PROC     FAR
040E  2E: C6 06 0069 R 04       C            MOV      CMDCT,4
0414  2E: C6 06 0005 R 5F       C            MOV      CMDBUF,UNT
041A  2E: C6 06 0006 R 3F       C            MOV      CMDBUF+1,UNL
0420  2E: C6 06 0007 R 40       C            MOV      CMDBUF+2,MA+100Q
0426  2E: A0 00D1 R             C            MOV      AL,DLA
042A  2E: A2 0008 R             C            MOV      CMDBUF+3,AL
042E  9A 0336 ---- R            C            CALL     CMD
0433  B0 10                     C            MOV      AL,GTS
0435  E6 45                     C            OUT      AUXMR,AL
0437  2E: 8B 1E 00CF R          C            MOV      BX,DATCT
043C  BE 006D R                 C            MOV      SI, OFFSET DATBUF
043F  9A 03E5 ---- R            C            CALL     DSEND
                                C  ;WRITE1            IN       AL,ISR1
                                C  ;         AND      AL,DO
                                C  ;         JZ       WRITE1
0444  B0 11                     C            MOV      AL,TCA
0446  E6 45                     C            OUT      AUXMR,AL
0448  2E: FE 0E 0069 R          C            DEC      CMDCT
044D  9A 0336 ---- R            C            CALL     CMD
0452  CB                        C            RET
0453                            C  WRITEGPIB          ENDP
                                C
                                C                     INCLUDE PASSGPIB.ASM
                                C  ;
                                C  ;
                                C  ;         ***********************************************
                                C  ;         *                                             *
                                C  ;         *         PASS    - PASS ADDRESSES OF BUFFERS *
                                C  ;         *                   TO CALLING PROGRAM        *
                                C  ;         *                                             *
                                C  ;         ***********************************************
                                C  ;
                                C  ;
                                C  ;
                                C  ;         CALLING SEQUENCE.
                                C  ;
                                C  ;                  CALL PASS(CIC,CMDBUF,CMDCT,DATBUF,DATCT,DLA,SRE,TCT,
                                C  ;                       VSEOI)
                                C  ;
                                C  ;                  WHERE THE PARAMETER ADDRESSES ARE DEFINED AS 16 BIT
                                C  ;                  WORDS AS FOLLOWS
                                C  ;
                                C  ;                  SYMBOL                   DEFINITION
                                C  ;
                                C  ;                  ---------------------------------------------------
                                C  ;
                                C  ;
                                C  ;                  CIC              CONTROLLER IN CHARGE FLAG
```

```
                                C ;                    CMDBUF          COMMAND BUFFER START ADDRESS
                                C ;                    CMDCT           COMMAND COUNT
                                C ;                    DATBUF          DATA BUFFER START ADDRESS
                                C ;                    DATCT           DATA BUFFER COUNT
                                C ;                    OLA             LISTEN ADDRESS/TALK ADDRESS OF DEVICE
                                C ;                    SRE             REMOTE ENABLE FLAG
                                C ;                    TCTADR          TCT ADDRESS OF ACTIVE CONTROLLER
                                C ;                    VSEOI           SEOI FLAG
                                C ;
                                C ;                    -------------------------------------------------------
                                C ;
                                C ;                    TOTAL NUMBER OF PARAMETERS = 9
                                C ;
                                C ;                    -------------------------------------------------------
                                C ;
                                C ;
 0453                           C PASS      PROC       FAR
 0453   8B EC                   C           MOV        BP,SP
 0455   8B 76 14                C           MOV        SI,20[BP]
 0458   C7 04 0000 R            C           MOV        WORD PTR [SI], OFFSET CIC
 045C   8B 76 12                C           MOV        SI,18[BP]
 045F   C7 04 0005 R            C           MOV        WORD PTR [SI], OFFSET CMDBUF
 0463   8B 76 10                C           MOV        SI,16[BP]
 0466   C7 04 0069 R            C           MOV        WORD PTR [SI], OFFSET CMDCT
 046A   8B 76 0E                C           MOV        SI,14[BP]
 046D   C7 04 006B R            C           MOV        WORD PTR [SI], OFFSET DATBUF
 0471   8B 76 0C                C           MOV        SI,12[BP]
 0474   C7 04 00CF R            C           MOV        WORD PTR [SI], OFFSET DATCT
 0478   8B 76 0A                C           MOV        SI,10[BP]
 047B   C7 04 00D1 R            C           MOV        WORD PTR [SI], OFFSET OLA
 047F   8B 76 08                C           MOV        SI,8[BP]
 0482   C7 04 00D2 R            C           MOV        WORD PTR [SI], OFFSET SRE
 0486   8B 76 06                C           MOV        SI,6[BP]
 0489   C7 04 00D3 R            C           MOV        WORD PTR [SI], OFFSET TCTADR
 048D   8B 76 04                C           MOV        SI,4[BP]
 0490   8C C8                   C           MOV        AX,CS
 0492   89 04                   C           MOV        WORD PTR [SI], AX
 0494   CA 0012                 C           RET        18
 0497                           C PASS      ENDP
                                C
                                C                      INCLUDE CLBFGPIB.ASM
                                C ;
                                C ;
                                C ;         *******************************************
                                C ;         *                                         *
                                C ;         *    CLEAR BUFFERS AND COUNTERS - CLBF    *
                                C ;         *                                         *
                                C ;         *******************************************
                                C ;
                                C ;
                                C ;
                                C ;
                                C ;
                                C ;
 0497                           C CLBF      PROC       FAR
 0497   B9 0064                 C           MOV        CX,100
 049A   BB 0005 R               C           MOV        BX, OFFSET CMDBUF
 049D   2E: 88 0F               C CMDZ:     MOV        BYTE PTR CS:[BX],CL
 04A0   43                      C           INC        BX
 04A1   E2 FA                   C           LOOP       CMDZ
 04A3   B9 0064                 C           MOV        CX,100
 04A6   BB 006B R               C           MOV        BX, OFFSET DATBUF
 04A9   2E: 88 0F               C DBFZ:     MOV        BYTE PTR CS:[BX],CL
 04AC   43                      C           INC        BX
```

```
      04AD   E2 FA                          C             LOOP     DBFZ
      04AF   2E: C6 06 00D1 R 34            C             MOV      OLA, 52
      04B5   2E: C6 06 006A R 00            C             MOV      COUNT, 0
      04BB   2E: C6 06 0000 R 00            C             MOV      CIC   , 0
      04C1   2E: C6 06 0069 R 00            C             MOV      CMDCT, 0
      04C7   2E: C7 06 00CF R 0000          C             MOV      DATCT, 0
      04CE   2E  C6 06 00D2 R 00            C             MOV      SRE   , 0
      04D4   2E  C6 06 00D3 R 00            C             MOV      TCTADR, 0
      04DA   2E  C6 06 00D4 R 00            C             MOV      VSEDI , 0
      04E0   CB                             C             RET
      04E1                                  C   CLBF      ENDP
                                            C
                                            C                      INCLUDE TIMEGPIB ASM
                                            C   ;
                                            C   ,
                                            C   ,         ***********************************************
                                            C   ,         *                                             *
                                            C   ;         *                   GPIBTIME                  *
                                            C   ;         *                                             *
                                            C   ;         ***********************************************
                                            C   ;
                                            C   ;
      04E1                                  C   GPIBTIME           PROC     FAR
      04E1   B4 2C                          C             MOV      AH, 2CH
      04E3   CD 21                          C             INT      21H
      04E5   2E: 89 0E 0001 R               C             MOV      T1, CX
      04EA   2E: 89 16 0003 R               C             MOV      T2, DX
      04EF   CB                             C             RET
      04F0                                  C   GPIBTIME           ENDP
                                            C
      04F0                                                         FUNC     ENDS
                                                                            END       INIT
```

Macros.

N a m e	Length
ERRNZ	0002
ERRZR	0002
POPALL	0003
PUSHALL	0003
RETF	0001
SVC	0001

Segments and groups:

N a m e	Size	align	combine class
FUNC	04F0	PARA	NONE

Symbols:

Name	Type	Value	Attr		
ADMR	Number	0044			
ADR	Number	0046			
ADR0	Number	0046			
ADR1	Number	0047			
ADSR	Number	0044			
AUXMR	Number	0045			
AUXRA	Number	0080			
AUXRB	Number	00A0			
AUXRE	Number	00C0			
BASE	Number	0040			
CDOR	Number	0040			
CIC	L BYTE	0000	FUNC	Global	
CIFC	Number	0016			
CLBF	F PROC	0497	FUNC	Global	Length =004A
CMD	F PROC	0336	FUNC	Global	Length =0012
CMDBUF	L BYTE	0005	FUNC	Length =0064	
CMDCT	L BYTE	0069	FUNC		
CMDZ	L NEAR	049D	FUNC		
CO	Number	0008			
COUNT	L BYTE	006A	FUNC		
CPTR	Number	0045			
CREN	Number	0017			
CSEND	F PROC	030C	FUNC	Global	Length =002A
CSEND1	L NEAR	031A	FUNC		
CSEND2	L NEAR	0333	FUNC		
CSEND3	L NEAR	0335	FUNC		
CSEND4	L NEAR	0312	FUNC		
DATBUF	L BYTE	006B	FUNC	Length =0064	
DATCT	L WORD	00CF	FUNC		
DATI	Number	0001			
DBFZ	L NEAR	04A9	FUNC		
DIR	Number	0040			
DL1	Number	0020			
DO	Number	0002			
DSEND	F PROC	03E5	FUNC	Global	Length =0029
DSEND1	L NEAR	03E7	FUNC		
DSEND2	L NEAR	0402	FUNC		
DSEND3	L NEAR	040A	FUNC		
DSEND4	L NEAR	040D	FUNC		
DT1	Number	0040			
DUMMY	L BYTE	00D5	FUNC	Length =0200	
ENDRX	Number	0010			
EOI	Number	0080			
EOSR	Number	0047			
ERR	Number	0004			
ERRCNT	L BYTE	0356	FUNC		
FH	Number	0003			
GPIBTIME	F PROC	04E1	FUNC	Global	Length =000F
GTS	Number	0010			
ICR	Number	0020			
IEPON	Number	0000			
IFC	F PROC	0348	FUNC	Global	Length =000E
IFC1	L NEAR	034F	FUNC		
IMR1	Number	0041			
IMR2	Number	0042			
INIT	F PROC	02D5	FUNC	Global	Length =0037
ISR1	Number	0041			
ISR2	Number	0042			
LTN	Number	0013			
LTNC	Number	001B			

```
LUN. . . . . . . . . . . . . . . .      Number  001C
MA . . . . . . . . . . . . . . . .      Number  0000
MODE1. . . . . . . . . . . . . . .      Number  0001
NATN . . . . . . . . . . . . . . .      Number  0040
NEXT . . . . . . . . . . . . . . .      L NEAR  0379    FUNC
OLA. . . . . . . . . . . . . . . .      L BYTE  00D1    FUNC
PASS . . . . . . . . . . . . . . .      F PROC  0453    FUNC    Global  Length =0044
PPR. . . . . . . . . . . . . . . .      Number  0060
RCV. . . . . . . . . . . . . . . .      F PROC  0357    FUNC    Global  Length =003F
RCV3 . . . . . . . . . . . . . . .      L NEAR  0364    FUNC
RCV5 . . . . . . . . . . . . . . .      L NEAR  038D    FUNC
RCV6 . . . . . . . . . . . . . . .      L NEAR  0394    FUNC
READGPIB . . . . . . . . . . . . .      F PROC  0396    FUNC    Global  Length =004F
SC . . . . . . . . . . . . . . . .      Number  0010
SEL0 . . . . . . . . . . . . . . .      Number  0000
SEL1 . . . . . . . . . . . . . . .      Number  0080
SEOI . . . . . . . . . . . . . . .      Number  0006
SIFC . . . . . . . . . . . . . . .      Number  001E
SPMR . . . . . . . . . . . . . . .      Number  0043
SPSR . . . . . . . . . . . . . . .      Number  0043
SRE. . . . . . . . . . . . . . . .      L BYTE  00D2    FUNC
SREN . . . . . . . . . . . . . . .      Number  001F
T1 . . . . . . . . . . . . . . . .      L WORD  0001    FUNC
T2 . . . . . . . . . . . . . . . .      L WORD  0003    FUNC
TCA. . . . . . . . . . . . . . . .      Number  0011
TCS. . . . . . . . . . . . . . . .      Number  0012
TCSE . . . . . . . . . . . . . . .      Number  001A
TCT  . . . . . . . . . . . . . . .      Number  0009
TCTADR . . . . . . . . . . . . . .      L BYTE  00D3    FUNC
TRM. . . . . . . . . . . . . . . .      Number  0030
UNL. . . . . . . . . . . . . . . .      Number  003F
UNT  . . . . . . . . . . . . . . .      Number  005F
VSEOI  . . . . . . . . . . . . . .      L BYTE  00D4    FUNC
WRITEGPIB  . . . . . . . . . . . .      F PROC  040E    FUNC    Global  Length =004[illegible]
XLOOP  . . . . . . . . . . . . . .      L NEAR  03A3    FUNC

Warning Severe
Errors  Errors
0       0
```

```
ADMR . . . . . . . . . . .    36#   174
ADR  . . . . . . . . . . .    40#   176   178
ADR0 . . . . . . . . . . .    39#
ADR1 . . . . . . . . . . .    41#
ADSR . . . . . . . . . . .    35#   339
AUXMR. . . . . . . . . . .    38#   168   180   238   257   261   279   284   287   305   331   333   338   345
                             373   401   409

AUXRA  . . . . . . . . . .    86#
AUXRB  . . . . . . . . . .    87#
AUXRE  . . . . . . . . . .    88#

BASE . . . . . . . . . . .    26#    27    28    29    30    31    32    33    34    35    36    37    38    39
                              40     41    42

CDOR . . . . . . . . . . .    28#   209   375
CIC. . . . . . . . . . . .   130#   280
CIFC . . . . . . . . . . .   105#   260
CMD. . . . . . . . . . . .    10    236#  243   329   343   399   411
CMDBUF . . . . . . . . . .   131#   239   320   321   323   325   394   395   396   398
CMDCT. . . . . . . . . . .   135#   240   326   328   342   393   410
CO . . . . . . . . . . . .    57#   202
COUNT. . . . . . . . . . .   136#   200   204   207
CPTR . . . . . . . . . . .    37#
CREN . . . . . . . . . . .   107#
CSEND. . . . . . . . . . .     9    199#  217   241
CSEND1 . . . . . . . . . .   201#   203   214
CSEND2 . . . . . . . . . .   212    215#
CSEND3 . . . . . . . . . .   206    216#

DATBUF . . . . . . . . . .   137#   335   403
DATCT. . . . . . . . . . .   141#   334   402
DATI . . . . . . . . . . .    48#   290
DIR. . . . . . . . . . . .    27#   294   301
DL1. . . . . . . . . . . .    65#   177
DO . . . . . . . . . . . .    49#   363   406
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DSEND2 . . . . . . . . . .   369    371   374#
DSEND3 . . . . . . . . . .   366    378#
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